INDOOR AIR QUALITY ASSESSMENT

North Reading Middle School
Sherman Road
North Reading, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
January 2004

Background/Introduction

At the request of Wayne Hardacker, Supervisor of Buildings and Grounds for the North Reading School Department, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at the North Reading Middle School (NRMS), Sharman Road, North Reading, Massachusetts. On October 24, 2003, a visit to conduct an indoor air quality assessment was made to this school by Cory Holmes, Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) program.

The school is a two-story brick building constructed in 1963. The school contains general classrooms, science classrooms, music/band rooms, a kitchen, cafeteria, gymnasium, library, health suite and office space.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

This school houses grades 6-8 and has a student population of approximately 620 and a staff of approximately 80. Tests were taken during normal operations at the school and results appear in Table 1.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million of air (ppm) in twenty-seven of thirty-nine areas surveyed, indicating inadequate ventilation in a number of areas. Fresh air in classrooms is supplied by a unit ventilator (univent) system. Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building (Picture 1) and return air through an air intake located at the base of each unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. The majority of univents were operating during the assessment. Univents are reported by Mr. Hardacker to be original equipment, which have been serviced and have had parts replaced through the years. Obstructions to airflow, such as papers and books stored on univents and items in front of univent returns were seen in a number of classrooms (Picture 2). In order for univents to provide fresh air as designed, intakes must remain free of obstructions.

Exhaust ventilation in classrooms consists of wall-mounted vents powered by rooftop motors. The exhaust system was not drawing and/or backdrafting in a number of areas surveyed, indicating that motors were deactivated or non-functional. Without adequate exhaust ventilation, excess heat and environmental pollutants can build up and lead to indoor air complaints. Items were also seen obstructing exhaust vents in classrooms (Picture 3). As with the univents, exhaust vents must remain free of obstructions to function as designed.

Elevated levels (i.e., >800 ppm) of carbon dioxide were also measured in the gymnasium. Mechanical ventilation in the gymnasium is provided by two ceiling mounted air handling units (AHUs). Both of the AHUs were observed as deactivated during the

assessment, therefore no mechanical means of fresh air was being introduced. The speech and language room does not have windows or mechanical ventilation; nor does the room have passive ventilation for air exchange.

In order to have proper ventilation with a mechanical supply and exhaust system, ventilation systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information on carbon dioxide see Appendix A.

Temperature readings ranged from 69 ^{o} F to 77 ^{o} F, which were very close to the BEHA comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70 ^{o} F to 78 ^{o} F in order to provide for the comfort of building occupants. A number of temperature control/comfort complaints were expressed by occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. It is also difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (e.g., univents obstructed, exhaust vents obstructed/not operating).

Relative humidity measurements ranged from 22 to 35 percent, which were below the BEHA comfort range. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Caulking around windows was missing/damaged in many areas. Some of the panes were loose and drafts were evident. Missing caulking and/or loose fitting windowpanes can make it difficult to control temperature and can allow a means for water penetration into the building. Replacement of caulking and repairs of window leaks are necessary to prevent water penetration and subsequent damage to building materials, which can lead to mold growth. School department officials reported that window replacement is part of an on-going capital project to improve the building envelope of the school. A number of classroom windows were replaced during the summer of 2003, with more reportedly to be replaced during the summer of 2004.

Roof drains are connected to PVC pipe that empties water against the side of the building (Picture 4), leaving characteristic stains on the exterior brick. Gutters and downspouts are designed to collect and divert rainwater away from the building. In their current condition, water can flow down and pool against the building, which leads to potential water damage.

Other Concerns

The faculty workroom contains three photocopiers and two lamination machines. Lamination machines can produce irritating odors during use. VOCs and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, D., 1992). The faculty workroom is not equipped with local exhaust ventilation, which allows these pollutants to build up and lead to indoor air quality complaints.

Classroom B8-A contained a clothes dryer. BEHA staff inspected the dryer to see if it was properly vented and found the flexible exhaust duct was kinked, preventing proper airflow (Picture 5). Dryers must be properly vented to remove excess heat, moisture and particulates.

Also of note was the amount of materials stored inside classrooms. In classrooms throughout the school, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provide a source for dusts to accumulate. These items, (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Dust can be irritating to eyes, nose and respiratory tract. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up.

Several classrooms contained dry erase boards and dry erase markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), (e.g., methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Conclusions/Recommendations

In view of the findings at the time of the assessment, the following recommendations are made:

1. Survey classroom univents to ascertain function and determine whether an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers throughout the school.

2. To maximize air exchange, operate all ventilation systems throughout the building (e.g., gym, auditorium, classrooms) continuously during periods of school occupancy independent of thermostat control. To increase airflow in classrooms, set univent controls to "high".
3. Inspect rooftop exhaust motors and belts for proper function, repair and replace as necessary.
4. Remove all blockages from univents and exhaust vents.
5. Install a passive vent in the door to the speech and language room to provide air exchange.
6. Consider having ventilation systems re-balanced every five years by an HVAC engineering firm.
7. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all non-porous surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
8. Continue with plans to replace windows throughout the school.
9. Install downspouts with elbow extensions to drain water away from the building.
10. Examine the feasibility of installing local exhaust ventilation in the teacher's workroom.
11. Reduce length of flexible dryer exhaust to facilitate airflow.

12. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

13. Consider adopting, the US EPA (2000) document, Tools for Schools, in order to provide self assessment and maintain a good indoor air quality environment at your building. The document can be downloaded from the Internet at *http://www.epa.gov/iaq/schools/index.html*.

14. For further building-wide evaluations and advice on maintaining public buildings, see the resource manual and other related indoor air quality documents located on the MDPH's website at *http://www.state.ma.us/dph/beha/iaq/iaqhome.htm*.

References

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BOCA. 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials and Code Administrators International, Inc., Country Club Hill, IL. Section M-308.1.1.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

Sanford. 1999. Material Safety Data Sheet (MSDS No: 198-17). Expo® Dry Erase Markers Bullet, Chisel, and Ultra Fine Tip. Sanford Corporation. Bellwood, IL.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

Picture 1

Univent Fresh Air Intake

Picture 2

Items Obstructing Univent Air Diffuser

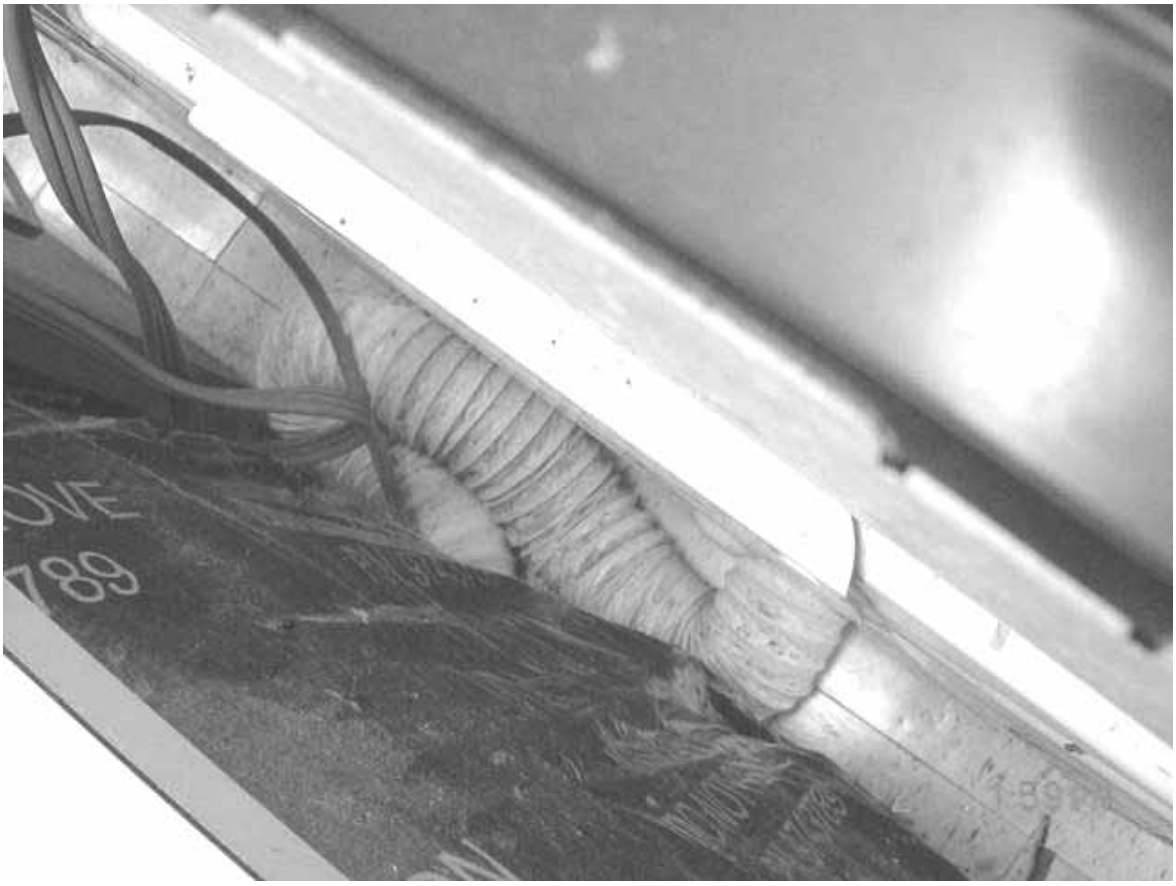
Picture 3

Exhaust Vent Obstructed by Bookcase

Picture 4

Roof Drain Empting against the Building

Picture 5



“Kinked” Flexible Dryer Vent in Classroom B8-A

Building: North Reading Middle School
Address: Sherman Road, North Reading, MA

Indoor Air Test Results
October 24, 2003

TABLE 1

Location/Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Background	55	26	390	-	-	-	-	Weather conditions: scattered clouds; NW winds 5-10 MPH
A-1 Computer Lab.	77	30	1431	30	Y	Y	Y	Supply blocked by clutter and boxes; exhaust blocked by furniture; PF; No AC
A-2	73	30	773	7	Y	Y	Y	Exhaust blocked by furniture; room sub-divided
A-21	73	25	705	1	Y	Y	Y	Exhaust off and back-drafting; DEM
A-22	73	33	2020	24	Y	Y	Y	Exhaust off and back-drafting; DEM
A-23	72	23	675	27	Y	Y	Y	Exhaust off; 2 windows open; heat complaint
A-24	74	27	885	23	Y	Y	Y	Hallway door open; exhaust off and back-drafting; DEM
A-25	72	35	1650	15	Y	Y	Y	Exhaust vent blocked-furniture
A-26	73	24	860	12	Y	Y	Y	1 open window

ppm = parts per million parts of air

AD = air deodorizer
AHU = air-handling unit
AP = air purifier
AC = air conditioning
CD = chalk dust
CT= ceiling tile
DEM = dry erase marker
DO = door open
MT= missing ceiling tile
PC = photocopier
PF = personal fan
TB = tennis balls
UF = upholstered furniture
WD = water damage

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

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Location/Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
A-27	73	30	1650	0	Y	Y	Y	27 occupants left 25 minutes prior to room assessment; exhaust blocked by furniture; DEM
A-28	69	30	1088	0	Y	Y	Y	7 occupants left 25 minutes prior to room assessment; Supply and exhaust blocked by furniture; DEM; PF; pens/pencils inside UV; desks are placed directly against UV
A-29	72	31	1378	29	Y	Y	Y	1 open window; hallway door open; DEM
A-3	73	29	1388	25	N	Y	Y	PF; DEM
A-31	71	35	1508	15	Y	Y	Y	Drafts around windows; exhaust off; door open; 5 WD-CTs
A-32	71	32	1018	16	Y	Y	Y	Heat reflection issues-roof; exhaust off-backdrafting; dust-windowsill; 1 WD-CT
A-4	73	25	772	9	Y	Y	Y	Hallway door open; DEM particles; cleaners
A-5a	73	26	765	0	Y	Y	N	DEM ; 1 WD-CT

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A-5b	73	26	805	3	N	Y	Y	Room subdivided; supply blocked by furniture; DEM
A-6	75	30	1525	20	N	Y	Y	Hallway door open; DEM
A-7	75	31	1230	0	N	Y	Y	Supply blocked by boxes; DEM
B-12	74	30	1099	25	Y	Y	Y	Art projects drying on UV; kiln in center of room-vented; UV and exhaust vent blocked
B-1a Curriculum Office	74	29	1055	3	Y	Y	N	Univent divided in half by wall; subdivided classroom
B-1b	75	24	630	4	Y	Y	Y	Univent divided in half
B-3	71	28	1184	27	Y	Y	Y	Windows open
B-4	74	25	756	2	Y	Y	Y	Exhaust blocked by furniture
B-5	73	25	693	0	Y	Y	Y	
B-6	73	28	1003	27		Y	Y	

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B-8a	74	29	1189	25	Y	Y	Y	Clothes dryer duct "pinched"; exhaust vent off; 2 WD-CTs
B-8b	75	28	847	31	Y	Y		Exhaust vent could not be identified; 3 WD-CTs
Cafeteria	69	33	976	200	Y	Y	Y	
Faculty Men's Room	-	-	-	-	-	-	Y	Open plumbing pipes
Guidance	73	27	750	3	Y	N	N	
Gym	71	32	1080	2	N	Y	Y	2 AHUs-off; 25 occupants gone 3 min.
LGR Lecture Hall	73	22	487	17				
Library	73	27	835	34	Y	Y	Y	Exhaust blocked by furniture
Main Office	73	28	855	2	Y	N	N	Window AC

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Pupil Personnel Services	72	26	823	2	Y	N	N	Window AC
Speech and Language	74	28	932	1	N	N	N	DEM
Superintendent Support Staff	74	26	694	3	Y	N	Y	Window AC
Teacher's Lounge	75	26	719	7	Y	Y	N	5 WD-CTs; 1 MT
Teacher's Workroom	73	31	1607	0	N	Y	N	No local exhaust ventilation; 3 photocopiers; 2 lamination machines

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